crystal display element or between a liquid crystal display element and a backlight there is provided a diffuse transmission type hologram capable of diffusing and transmitting light incident from a specific direction only in a direction defined as a viewing region, it is possible to make wide a visual field region where displayed images can be observed and reduce luminance drops, so that bright displayed images can be presented. It is here to be noted that the present invention may be modified such that the visual field range can be arbitrarily set to observe images only in a plurality of different directions, and it is not always required to locate a scatter plate on the backlight side.

According to the second inventive liquid crystal display device using a hologram wherein on a back surface side of a liquid crystal display element opposite to a display surface side thereof there is provided a diffuse reflection type hologram capable of diffusing and reflecting light incident from a specific direction only in a direction defined as a viewing region as mentioned above, it is possible to present bright displays in the light without recourse to any self-luminous type backlight.

According to the inventive hologram scatter plate wherein a transmission type hologram layer and a back side layer are stacked together in the described order, it is possible to limit the direction of diffraction and scattering by means of the transmission hologram and increase reflectance over a wide wavelength region by means of the back side layer, so that diffused light having high,luminance can be obtained over a wide wavelength and viewing angle range, so making bright displays, etc. possible. It is here to be noted that the transmission type hologram layer, if it has diffraction function, or diffusion function and diffraction function, with respect to a plurality of different wavelengths, especially, three wavelengths in R, G and B regions, can then present displays brighter (three times as bright on calculation) than those obtained with a hologram layer having diffraction function, or diffusion function and diffraction function, with respect to a single wavelength.

According to the inventive diffuse reflection type hologram replication process wherein while a photosensitive material film is slid on a fixed diffuse type hologram plate in contact relation thereto, the hologram plate is irradiated from the photosensitive material film with a light beam of linear section that becomes wide in a widthwise direction of the film, so that a diffuse reflection type hologram can be continuously recorded in the photosensitive material film by interference of the incident light beam with a light beam reflected and diffracted by the diffuse reflection type hologram plate, it is possible to easily fabricate, with no need of using any large hologram plate, a large yet continuous film form of diffuse reflection type hologram having neither joints nor recorded joints therein, which has high reflectance and quality, and so is best suited for use with backlights, projector screens, combiners, etc. for liquid crystal display devices.

What we claim is:

1. A liquid crystal display device using a hologram, characterized in that a liquid crystal display element is provided on a back surface side thereof opposite to a display surface side thereof with a diffuse reflection type hologram itself capable of diffusing and reflecting light of selected wavelengths incident from a specific direction only in a direction defined as a viewing region, wherein said hologram has a different optical function with respect to different respective wavelengths, wherein the diffuse reflection type hologram comprises a duplicate hologram of a single photosensitive layer.

2. A liquid crystal display device using a hologram, characterized in that a liquid crystal display element is provided on a back surface side thereof opposite to a display surface side thereof with a diffuse reflection type hologram itself capable of diffusing and reflecting light of selected wavelengths incident from a specific direction only in a direction defined as a viewing region, wherein said hologram has a different optical function with respect to different respective wavelengths, wherein the diffuse reflection type hologram comprises a plurality of layers including:

a first hologram recorded on a first photosensitive material using a wavelength produced by a Kr laser;

a second hologram recorded on a second photosensitive material using a wavelength produced by at least one of an Ar and a dye laser;

a third hologram recorded on a third photosensitive material using a wavelength produced by an Ar laser.

3. The liquid crystal display device of claim 2, wherein a color tuning film is laminated on the hologram, wherein said color tuning film broadens a diffraction wavelength range of said hologram layer.

4. A liquid crystal display device using a hologram, characterized in that a liquid crystal display element is provided on a back surface side thereof opposite to a display surface side thereof with a diffuse reflection type hologram itself capable of diffusing and reflecting light of selected wavelengths incident from a specific direction only in a direction defined as a viewing region, wherein said hologram has a different optical function with respect to different respective wavelengths,

characterized in that a diffuse reflection plate or a reflector plate is located on the back surface side of the diffuse reflection type hologram,

wherein the diffuse reflection type hologram comprises a plurality of layers including:

a first hologram recorded on a first photosensitive material using a wavelength produced by a Kr laser;

a second hologram recorded on a second photosensitive material using a wavelength produced by at least one of an Ar and a dye laser;

a third hologram recorded on a third photosensitive material using a wavelength produced by an Ar laser.

5. A liquid crystal display device using a hologram, characterized in that a liquid crystal display element is provided on a back surface side thereof opposite to a display surface side thereof with a diffuse reflection type hologram itself capable of diffusing and reflecting light of selected wavelengths incident from a specific direction only in a direction defined as a viewing region, wherein said hologram has a different optical function with respect to different respective wavelengths,

characterized in that a diffuse reflection plate or a reflector plate is located on the back surface side of the diffuse reflection type hologram,

characterized in that a polarizing plate, a hologram, a color tuning film and a reflecting layer are laminated together in order from a liquid crystal side.

6. A liquid crystal display device of claim 5, characterized in that said hologram is a color hologram with interference fringes recorded thereon in such a way as to diffract a plurality of wavelengths including red, green and blue wavelengths.

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According to the second inventive liquid crystal display device using a hologram wherein on a back surface side of a liquid crystal display element opposite to a display surface side thereof there is provided a diffuse reflection type hologram capable of diffusing and reflecting light incident from a specific direction only in a direction defined as a viewing region as mentioned above, it is possible to present bright displays in the light without recourse to any self-luminous type backlight.

According to the inventive hologram scatter plate wherein a transmission type hologram layer and a back side layer are stacked together in the described order, it is possible to limit the direction of diffraction and scattering by means of the transmission hologram and increase reflectance over a wide wavelength region by means of the back side layer, so that diffused light having high luminance can be obtained over a wide wavelength and viewing angle range, so making bright displays, etc. possible. It is here to be noted that the transmission type hologram layer, if it has diffraction function, or diffusion function and diffraction function, with respect to a plurality of different wavelengths, especially, three wavelengths in R, G and B regions, can then present displays brighter (three times as bright on calculation) than those obtained with a hologram layer having diffraction function, or diffusion function and diffraction function, with respect to a single wavelength.

According to the inventive diffuse reflection type hologram replication process wherein while a photosensitive material film is slid on a fixed diffuse type hologram plate in contact relation thereto, the hologram plate is irradiated from the photosensitive material film with a light beam of linear section that becomes wide in a widthwise direction of the film, so that a diffuse reflection type hologram can be continuously recorded in the photosensitive material film by interference of the incident light beam with a light beam reflected and diffracted by the diffuse reflection type hologram plate, it is possible to easily fabricate, with no need of using any large hologram plate, a large yet continuous film form of diffuse reflection type hologram having neither joints nor recorded joints therein, which has high reflectance and quality, and so is best suited for use with backlights, projector screens, combiners, etc. for liquid crystal display devices.

What we claim is:

1. A liquid crystal display device using a hologram, characterized in that between a liquid crystal display element and a backlight there is located a diffuse transmission type hologram optically configured to diffuse and transmit white light therethrough from light that is incident on said hologram from a specific direction, said hologram diffusing and transmitting light in a direction defined as a viewing region, wherein said hologram transmits white light symmetrically about a line of incidence through a planar surface of the hologram.

2. The liquid crystal display of claim 1, wherein said hologram transmits said white light without substantial color component separation.

3. The liquid crystal display of claim 2, wherein the hologram transmits white light symmetrically about a normal line to the planar surface of the hologram.

4. The liquid crystal display of claim 2, wherein the hologram operably diffuses and transmits light in a region bounded by an imaginary plane, wherein the region is larger than a planar region of the hologram.

5. A hologram scatter plate which reflects incident light in a direction different from a direct reflection direction, characterized in that a transmission type hologram layer and a back side layer are stacked together in the described order as viewed from an incident side thereof, wherein the transmission type hologram layer has both a diffusion function and an off-axis diffraction function while the back side layer is a mirror reflection layer and has no diffusion and diffraction functions.

6. A hologram scatter plate which reflects incident light in a direction different from a direct reflection direction, characterized in that a transmission type hologram layer and a back side layer are stacked together in the described order as viewed from an incident side thereof, wherein the transmission type hologram layer has an off-axis diffraction function while the back side layer has a diffuse reflection function.

7. A hologram scatter plate which reflects incident light in a direction different from a direct reflection direction, characterized in that a transmission type hologram layer and a back side layer are stacked together in the described order as viewed from an incident side thereof, wherein the transmission diffraction type hologram layer has both diffusion function and an off-axis function while the back side layer has a diffuse reflection function.

8. The hologram scatter plate according to any one of claims 5 to 7, characterized in that the transmission type hologram layer has a different respective diffraction function, or diffusion and diffraction function, for different respective wavelengths.

9. A liquid crystal display device, characterized by having the hologram scatter plate according to claim 8 located on a back surface side of a liquid crystal display element.

10. A liquid crystal display device, characterized by having the hologram scatter plate according to any one of claim 5 to 7 located on a back surface side of a liquid crystal display element.

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